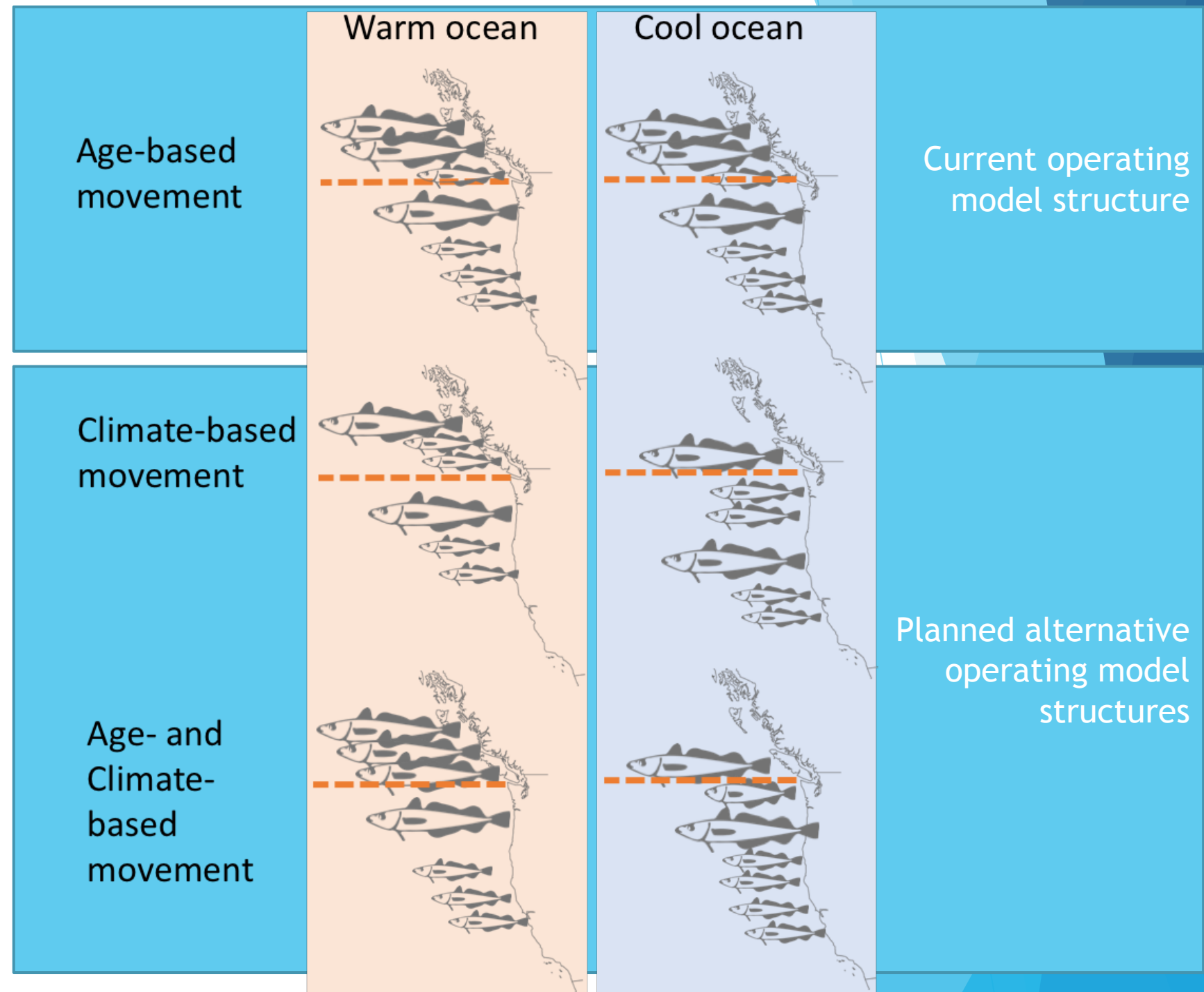# Hake MSE - planned steps and scenarios for climate

JMC/MSEWG meeting

May 2019

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With contributions from Aaron Berger, Nis Jacobsen, Ian Taylor

Alternative hypotheses for movement (operating models)

Warm ocean | Cool ocean

Age-based movement

Climate-based movement

Age- and Climate-based movement

Current operating model structure

Planned alternative operating model structures

Develop model structure and climate scenarios

Planned steps include:

► Incorporate the findings of Mike Malick's work under the Fisheries And The Environment (FATE) project

► Modeling trends and/or regime-like patterns of variability in movement

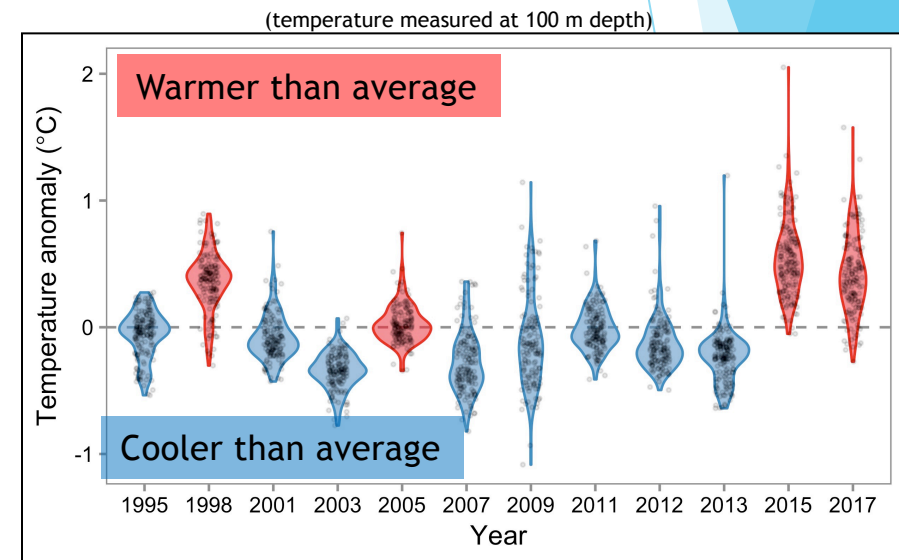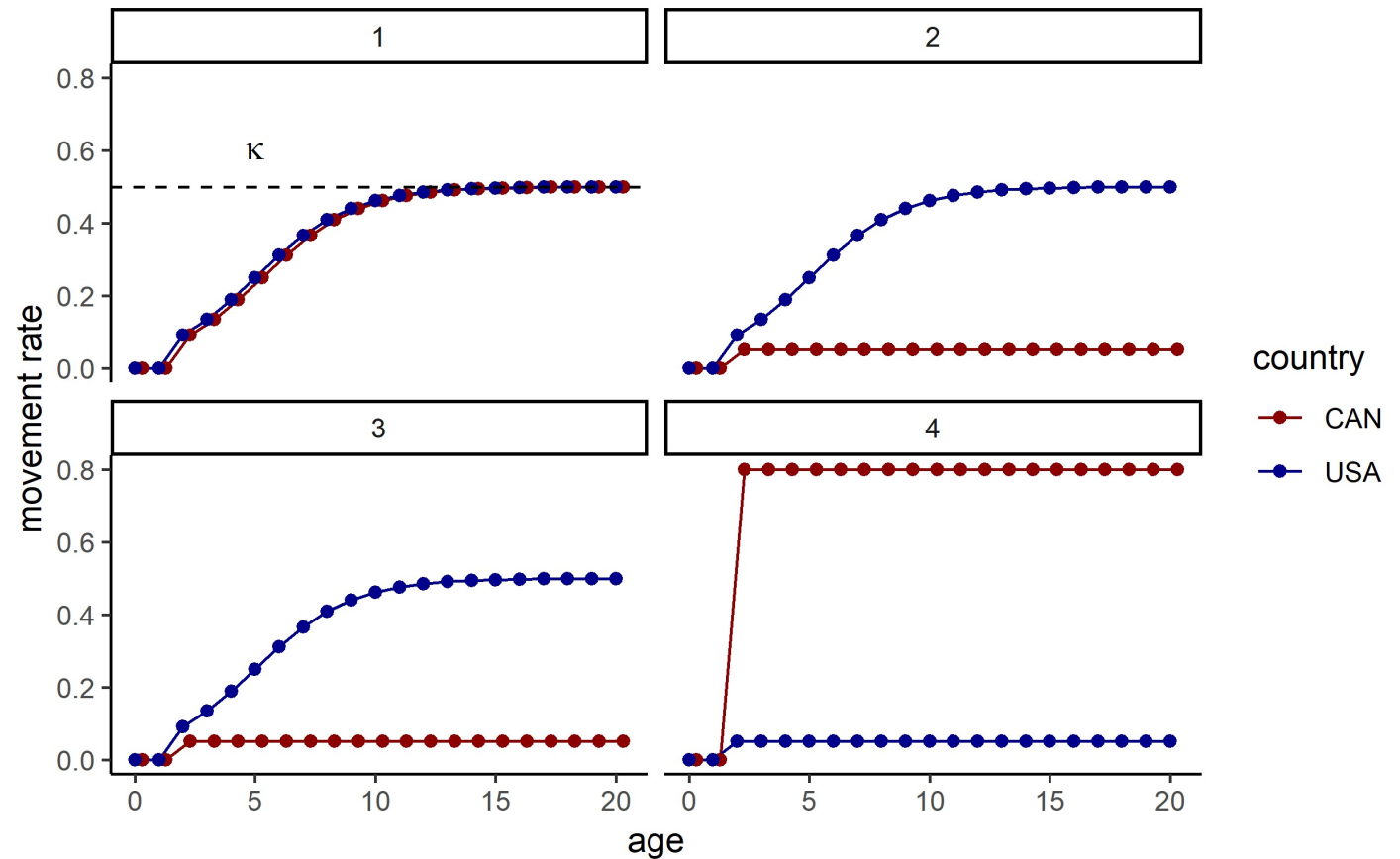(temperature measured at 100 m depth)

Figure from Mike Malick's talk to 2019 SRG

Current model structure for movement
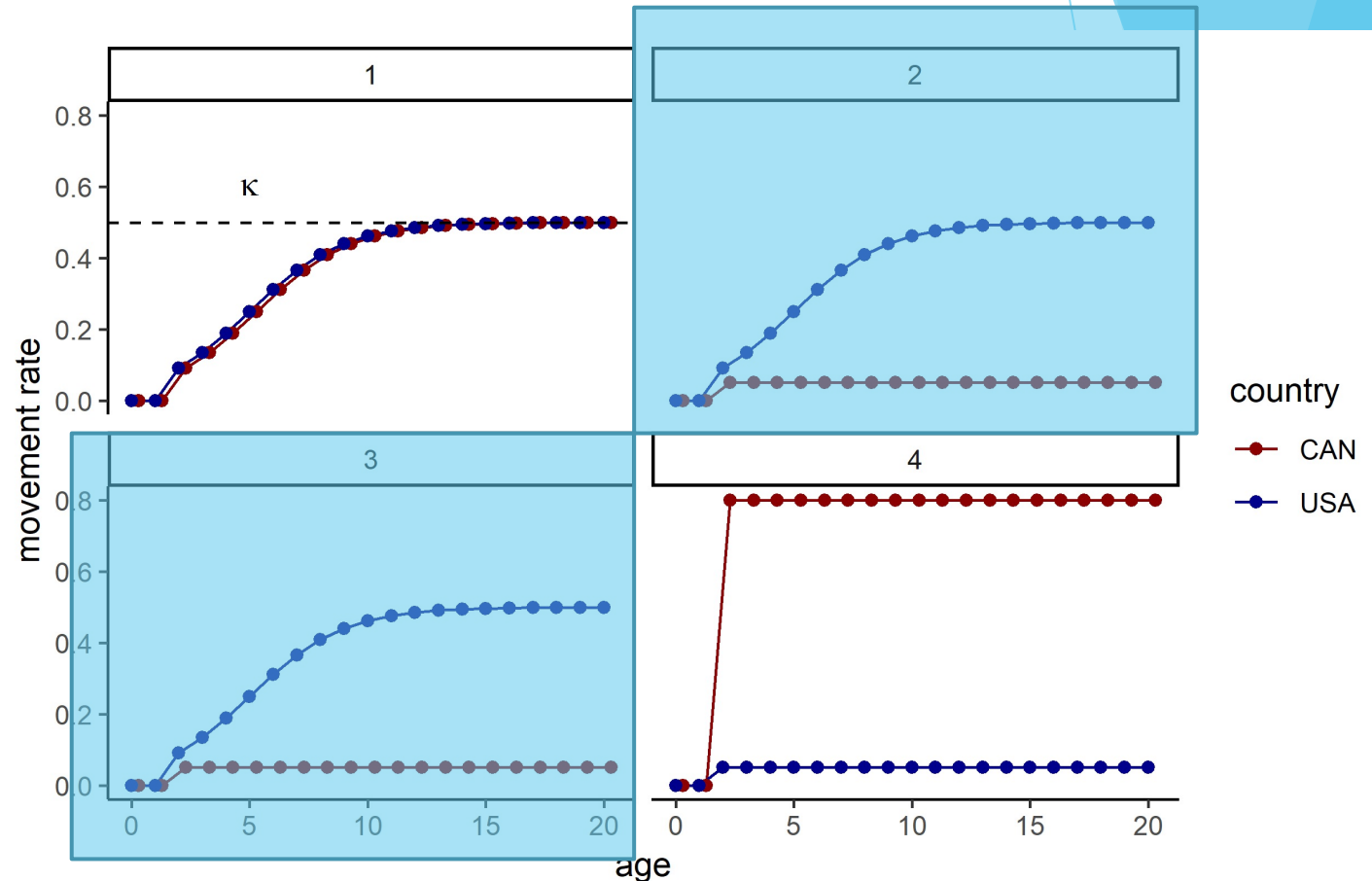
$$\omega_a = \frac{\kappa_i}{1 + e^{-\gamma a - a_{50}}}$$

Potential time-varying movement

- Time-varying movement in seasons 2 and 3
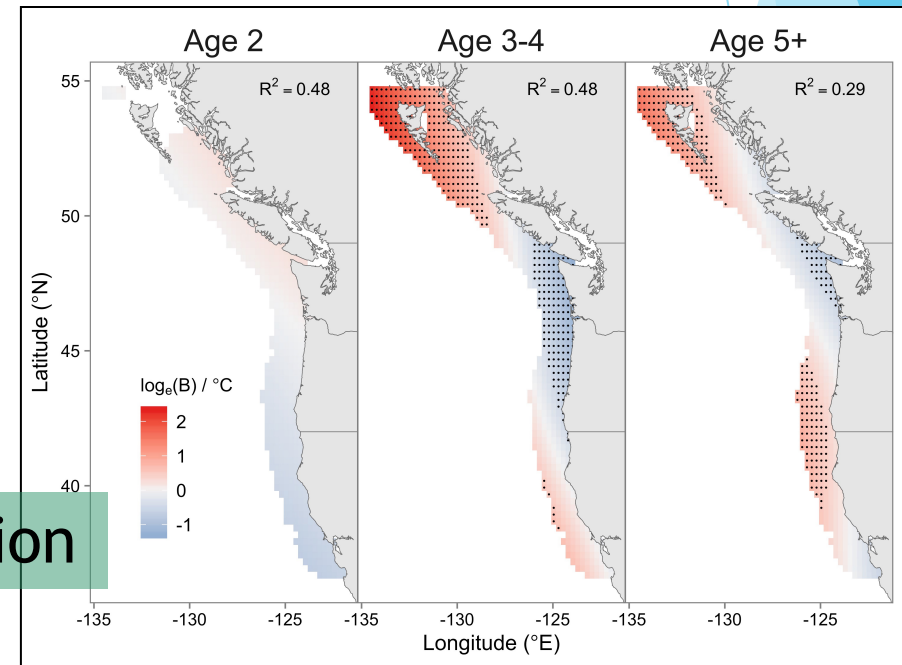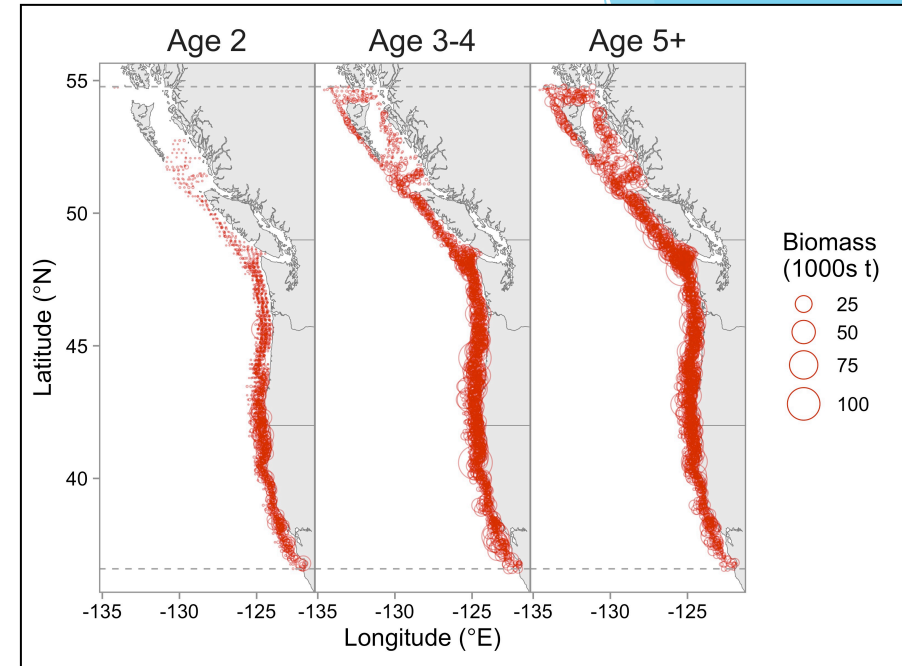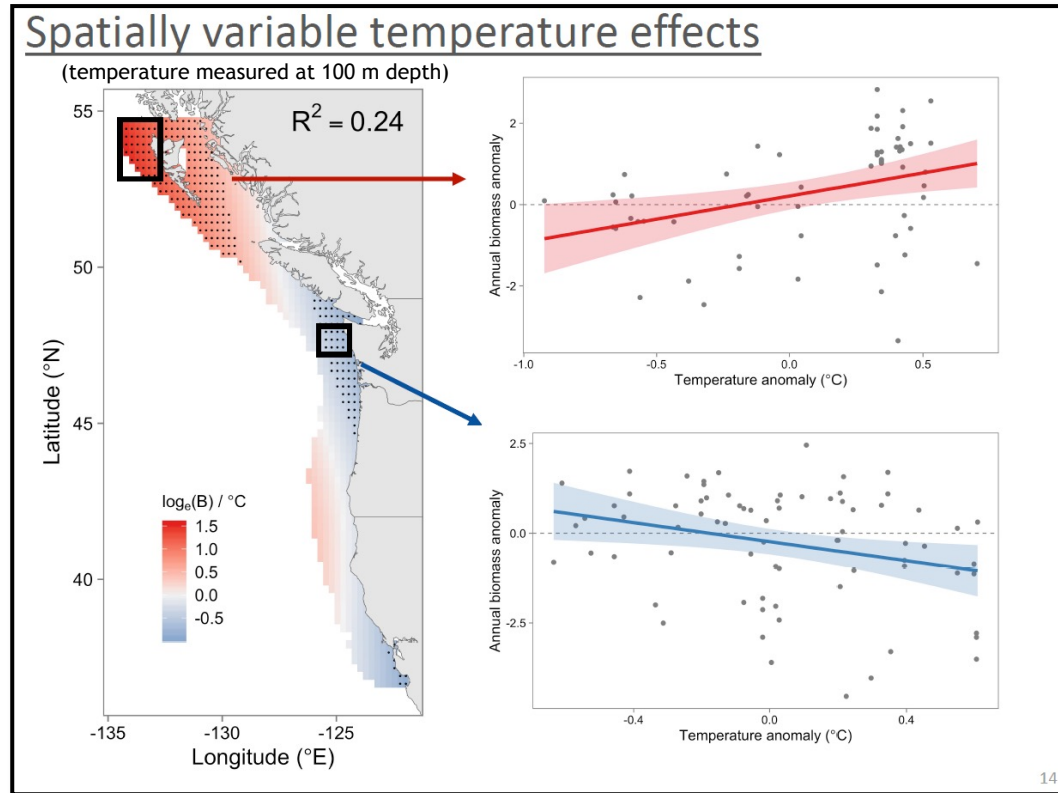
- Vary maximum movement rate in "warm" and "cool" years

$$\omega_a = \frac{\kappa_{it}}{1 + e^{-\gamma a - a_{50}}}$$

$$\kappa_{it} = f(T)$$

FATE project

Environmental drivers of Hake distribution

Seasonal forecasting of spatial distribution

Figures from Mike Malick's talk to 2019 SRG

Potential hypothesis about the effect of the future **environment** on movement:

- Status quo: no change in future environment

- Trend (continuous increase or decrease) in movement rate with warming conditions

- Movement may exhibit regime-like patterns or follow an ENSO-like signal

- Variability in movement could increase in an unpredictable way

*Goal of this is to characterize how robust hake management is to uncertainty in future environmental conditions and how they may affect fish distribution, not make forecasts

Other model structures/scenarios that could guide future MSE work

- Recruitment scenarios
  - What are the effects of large and small recruitment events?
  - What are the environmental drivers of recruitment and how will future environmental conditions affect recruitment?
- Growth scenarios
  - How could growth change through time with environmental conditions?